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A FOUR-YEARS' COLLEGE COURSE IN AGRICULTURE.

[Summary of reports 1–5 and 8 of the Committee on Methods of Teaching Agriculture of the Association of American Agricultural Colleges and Experiment Stations.[a]]

In planning a four-years' course for agricultural colleges the committee on teaching agriculture of the Association of American Agricultural Colleges and Experiment Stations followed the report of the committee on entrance requirements which had been adopted by the association.[b]

That portion of the report of the committee on entrance requirements, which relates to the subject essential to all courses, is as follows:

> In the judgment of your committee, it is not too much to require the equivalent of fifteen hours per week of recitations and lectures, together with ten hours per week of laboratory work, or practicums, including the time devoted to military science and drill. Upon this basis the above-mentioned general studies should be assigned a relative importance, approximately, as follows:

	Hours.		Hours.
Algebra	75	Modern languages	340
Geometry	40	Psychology	60
Trigonometry	40	Ethics or logic	40
Physics (class-room work)	75	Political economy	60
Physics (laboratory work)	75	General history	80
Chemistry (class-room work)	75	Constitutional law	50
Chemistry (laboratory work)	75		
English	200	Total	1,285

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[a] The committee responsible for reports 1–5 was composed of J. H. Connell, chairman, A. C. True, T. F. Hunt, H. T. French, and H. H. Wing. The committee responsible for subsequent reports is composed of A. C. True, chairman, H. H. Wing, T. F. Hunt, H. T. French, and J. F. Duggar. The complete reports of the committee will be found in U. S. Dept. Agr., Office of Experiment Stations Buls. 41, p. 57; 49, p. 29; 65, p. 79; 76, p. 37; 99, p. 86; 115, p. 56; 123, p. 45; 142, p. 63; 153, p. 43; and 164, p. 37.

[b] See U. S. Dept. Agr., Office of Experiment Stations Bul. 41, p. 52.

The total number of hours included in a four-years' course, allowing fifteen hours per week for thirty-six weeks, would be 2,140; with ten hours' laboratory work, or practicums added, 3,600. In general terms, therefore, the foregoing general studies should comprise about two-fifths of the work required for a bachelor's degree.

The committee on methods of teaching agriculture suggested additional subjects to be included in a four-years' course in agriculture, leading to the degree of bachelor of science, as follows:

	Hours.
Agriculture	486
Horticulture and forestry	180
Veterinary science, including anatomy	180
Agricultural chemistry, in addition to general requirement	180
Botany (including vegetable physiology and pathology)	180
Zoology (including entomology)	120
Physiology	180
Geology	120
Meteorology	60
Drawing	60
Total	1,746

In reckoning the number of hours, two hours of laboratory work, or practicums, are considered the equivalent of one hour of recitation. In this way the total number of hours in a four-years' course is made 2,900, instead of 3,600, as proposed by the committee on entrance requirements.

Agriculture was divided into the following branches:

Agriculture	1. Agronomy, or agriculture (technical).	Climate, soils, fertilizers, and crops—plant production.
	2. Zootechny, or animal industry.	Animal physiology and animal production.
	3. Agrotechny, or agricultural technology.	Agricultural industries, e. g., dairying, sugar making.
	4. Rural engineering, farm mechanics, or farm equipment.	Roads, drains, irrigation systems, farm buildings, etc.
	5. Rural economics, or farm management.	General policy of farm management, rural law, agricultural bookkeeping, etc.

The committee also submitted the following suggestions regarding the course of study to be included under the head of "Agriculture." The number of hours to be assigned to each of these general subjects is stated, as well as the main topics to be included under each general subject, and, in some cases, the text-books which may be used in connection with the teaching of particular subjects. These books were, however, named because they were considered by the committee as the best text-books then available on the subjects. They may also serve to show in a general way what would properly be included in the course under the several topics to which they apply. Some notes regarding equipment requisite for teaching the different branches included in this scheme are also given. The number of hours assigned to the different subjects is intended to apply to the average conditions of a four-years' course in agriculture. Local conditions will, of course, call for more or less modifications of the scheme here proposed.

Agriculture (486 hours) shall include:

	Hours.
1. Agronomy, or plant production	132
2. Zootechny, or animal industry	162
3. Agrotechny, or agricultural technology	72
4. Rural engineering, or farm mechanics	60
5. Rural economics, or farm management	60
Total	486

SYNOPSIS OF COURSE IN AGRICULTURE.

Agronomy .... 132 hours.

Climate Soils Tillage, drainage, and irrigation	F. H. King—The Soil.
Fertilizers	I. P. Roberts—The Fertility of the Land.
Plant production Farm crops	G. E. Morrow and T. F. Hunt—Soils and Crops.

Zootechny .... 162 hours.

Principles of breeding	M. Miles—Stock Breeding.
Breeds of live stock	G. W. Curtis—Horses, Cattle, Sheep, and Swine.
Stock, feeding, care, and management	H. P. Armsby—Manual of Cattle Feeding.

(Animal physiology to be taught under physiology; anatomy and animal diseases, under veterinary science.)

Agrotechny .... 72 hours.

Butter making	H. H. Wing—Milk and its Products. H. B. Gurler—American Dairying.
Cheese making	J. W. Decker—Cheddar Cheese Making.

(Other topics, such as sugar making, wine, or olive-oil making, may be taught under this head in different parts of the United States.)

Rural engineering .... 60 hours.

Roads, drains, irrigation systems, farm buildings, and machinery.

Rural economics .... 60 hours.

History of agriculture.

Farm management, rural law, farm accounts.

EQUIPMENT FOR COURSE IN AGRICULTURE.

The following brief statements may serve to show in a general way the equipment required in connection with the instruction given in a four-years' course in agriculture:

Agronomy.

Field trials of various crops for class demonstration.

Laboratory (including glass house) for work in soil physics, pot experiments, etc. This laboratory should have a floor space of from 1,000 to 2,000 square feet.

Collection of soils, fertilizers, plants, etc., for class illustration.

Photographs, lantern slides, charts, diagrams.

Books of reference.

Zootechny.

Live stock of different types and breeds.

Lecture room, arranged for exhibiting live animals to class and equipped with instruments of precision for weighing and measuring.

Collections: Models, mounted specimens of animals, specimens of foods, etc.

Lantern slides, photographs, charts, etc.

Reference books, especially herdbooks and stock registers. (There should be a seminary room for the use of these books.)

Agrotechny.

Dairy laboratory (this should include the following rooms, which may cover some 6,000 feet of floor space): Butter-making room, cheese-making room, cheese-curing room, pasteurizing room, receiving room, storeroom, refrigerating room, boiler and engine room. These rooms should be equipped with all modern apparatus for testing and pasteurizing milk and making butter and cheese.

Rural engineering.

College farm should illustrate various problems in farm engineering, such as roads, drainage, and irrigation.

Laboratory, equipped with apparatus for illustrating various mechanical problems in farm machinery.

Collections: Tools and farm machinery.

Lantern slides, charts, and diagrams.

Reference books.

Rural economics.

Reference books.

The committee presented its third report in three divisions, as follows:

(1) A syllabus defining the limits of a course in Agronomy and stating the topics included in Agronomy in the order in which they should be presented to students, i. e., in their logical and pedagogical order.

(2) A series of lecture or chapter headings showing how the syllabus for Agronomy may be applied in preparing a course of lectures or a text-book on this subject, covering 99 class-room hours or periods of 60 minutes each, i. e., three lecture or recitation periods a week.

(3) A series of subjects for practicums or laboratory exercises to be used in connection with the class-room work in Agronomy and covering the 33 remaining hours or periods (equivalent to 66 hours of 60 minutes each) assigned to the course in Agronomy, i. e., one practicum per week.

It has been the object of the committee to make such an outline of this course as can easily be adjusted to the requirements of institutions with different organization and environment. While the syllabus is intended to limit the range of subjects which may properly be included under Agronomy, the amount of attention which shall be given to particular topics will vary according to circumstances. The series of chapters and practicums are in a measure intended simply to show a way in which the subject of Agronomy may be presented in actual practice. This is especially true of that portion of the course which relates to individual farm crops, to which attention will naturally be given according to their relative importance in different localities.

SYLLABUS OF COURSE IN AGRONOMY.

- **Definition** .... Theory and practise of the production of farm crops. In Agronomy we need to consider the several kinds of plants grown as farm crops under the following subjects:
- **The plant** ....
  - Structure (anatomy).
  - Composition.
  - Physiology.
  - Environment.
- **Plant production** .... In agriculture has for its object the adaptation of environment to the anatomy and physiology of the plants under cultivation, with a view to securing crops which are best suited to the uses of man or the domestic animals.

We may conveniently begin the study of plant production by considering the general characteristics of the environment of plants as grown in the field.

- **Environment** .... (General factors.)
  - Light.
  - Heat.
  - Moisture
  - Air
  - Soil
    - Natural
    - With fertilizers
  - Moisture, Air, Soil: Plant food.

But environment may be conveniently divided according to position, as follows:

- **Environment** .... (Divided according to position.) (Chapters I-III of lecture outline page 7.)
  - 1. Above ground (climate)
    - Light
    - Heat
    - Moisture
    - Air
    - Study the relation of each of these factors to plant growth, and also briefly their effects in different combinations, i. e., different climates.
  - 2. Under ground (soil)
    - Heat
    - Moisture
    - Air
    - Earth (soil)
    - Fertilizers
    - Point out that the relation of these factors to plant growth may be most clearly perceived by first considering them in their relation to each other.

- **Soil** .... (Chapters IV-XXXI.)
  - Definition—Nature.
  - Functions.
  - Origin ......
    - Brief geological outline.
    - Weathering of rocks.
    - Accumulation of organic matter.
    - Transformation of organic matter (nitrification and denitrification, etc.).
    - Additions from atmosphere.
  - Properties ..
    - Chemical.
    - Physical ....
      - Weight
      - Color
      - Texture
      - Capillarity
      - Permeability
      - Absorptive power
    - Classification of soils, on the basis of their properties.
  - Temperature.
  - Air.

- **Soil**—Continued (Chapters IV-XXXI.)
  - Moisture
    - Sources
    - Amounts
      - Water table.
      - Hydroscopic moisture.
      - Rainfall.
      - Irrigation—Methods.
    - Drainage
      - Purpose and effects.
      - Methods.
    - Conservation
      - Purpose.
      - Methods.
  - Tillage
    - Purpose and effects
      - Chemical.
      - Physical.
      - Biological.
    - Methods.
  - Fertilizers
    - Definition.
    - Methods and effects of action
      - Chemical.
      - Physical.
      - Biological.
    - Classification
      - 1. According to constituents—
        - *a.* Nitrogenous.
        - *b.* Phosphoric.
        - *c.* Potassic.
        - *d.* Other amendments.
      - 2. According to form—
        - *a.* Green manures
        - *b.* Animal manures
          - Farm manures.
        - *c.* Commercial—classify principal forms.
    - (Study first the general theory of fertilizers according to above scheme, and then consider in as much detail as may be deemed desirable different kinds of fertilizers, using Schedule A.)
    - SCHEDULE A.
    - Kinds of fertilizers
      - Name.
      - Description.
      - Properties
        - Chemical—composition.
        - Physical.
      - Place in classifications.
      - Sources.
      - Uses.
      - Preparation, care, and handling.
      - Application.
      - Effects
        - Chemical.
        - Physical.
        - Biological.
      - Economy
        - Extent of production.
        - Pecuniary value.
  - Waste and renovation
    - Washing.
    - Transportation by wind and water.
    - Leaching.
    - Oxidation.
    - Cropping—rotation of crops—systems of farming.

Having considered in a general way the theory and practise of plant production as related to the structure, physiology, and environment of the plants grown as farm crops, we come next to consider the production of different kinds of crops more in detail.

- **Farm crops** (Chapters XXXII–XXXIII.)
  - Classification (The classification and the kinds of plants to be named under each class will vary according to circumstances.)
    - Cereals—wheat, oats.
    - Grasses—timothy, brome grass.
    - Legumes—red clover, alfalfa.
    - Tubers—potatoes.
    - Roots—mangels.
    - Sugar plants—sugar cane, sugar beets.
    - Fibers—cotton, flax, hemp.
    - Stimulants—tobacco, tea, coffee.
    - Medicinal and aromatic plants—ginseng, mint.
    - Miscellaneous—canaigre, peanuts.
  - Methods of improvement
    - Breeding.
    - Selection.

Next study individual farm crops according to the following scheme:

- **Individual farm crops.** (Chapters XXXIV–LXI.) (The crops to be studied will vary according to locality and other circumstances.)
  - Name.
  - Place in classification.
  - Structure.
  - Composition.
  - Physiology.
  - Botanical relations.
  - Varieties
    - Classification.
    - Improvement.
  - Geographical distribution.
  - Culture
    - Choice and preparation of soil.
    - Manuring.
    - Seeds (or other parts of plants used for planting) — selection — amount — treatment.
    - Planting.
    - Cultivating.
    - Place in rotation.
  - Harvesting.
  - Preservation.
  - Uses.
  - Preparation for use.
  - Obstructions to growth, preservation, or use
    - Weeds
    - Fungi
    - Bacteria
    - Insects
    - Birds
    - Quadrupeds
      - Means of repression.
  - Production.
  - Marketing.
  - History.

OUTLINE FOR A COURSE OF LECTURES OR A TEXT-BOOK ON AGRONOMY.

(The lectures are intended to cover 99 hours.)

Chapter I. General Climatic Conditions.
II. Plant Food and Growth.
III. Air as a Source of Plant Food.
IV. The Nature, Functions, Origin, and Wasting of Soils.
V. Properties of Soils, Chemical and Physical. Classifications, Texture, Composition, and Kinds of Soils.

Chapter VI. Physics of Soils as Related to Plant Growth (Capillarity, Solution, Diffusion, and Osmosis).
VII. Soil Temperature.
VIII. Relation of Air to Soil.
IX. Soil Water.
X. Irrigation.
XI. Improvement of Soil Thru Drainage.
XII. Drainage Methods.
XIII. Conservation of Soil Moisture.
XIV. Physical Effects of Tillage.
XV. Chemical and Biological Effects of Tillage.
XVI. Methods of Tillage.
XVII. Methods of Tillage.
XVIII. Fertilizers—Methods and Effects of Action.
XIX. Fertilizers—Classification by Constituents and Form.
XX. Sources and Uses of Nitrogen.
XXI. Sources and Uses of Phosphoric Acid.
XXII. Sources and Uses of Potash.
XXIII. Sources and Uses of Other Amendments.
XXIV. Practical Advice on the Use of Commercial Fertilizers.
XXV. Humus and Green Manuring.
XXVI. Animal Manures. General Statements.
XXVII. Manures Produced from Various Animals.
XXVIII. Care, Preservation, and Application of Manure.
XXIX. Waste and Renovation of Soils.
XXX. Rotation of Crops. General Statements.
XXXI. Rotation of Crops. Systems of Farming.
XXXII. Farm Crops—Classification, Production; Reasons for Choice.
XXXIII. Improvement of Farm Crops.
XXXIV. Wheat—Structure, Composition, and Varieties.
XXXV. Wheat—Culture, Harvesting, and Preservation.
XXXVI. Wheat—Obstructions to Growth, Preservation, and Use.
XXXVII. Wheat—Production, Marketing, History.
XXXVIII. Corn.
XXXIX. Corn.
XL. Corn.
XLI. Corn.
XLII. Rice.
XLIII. Oats.
XLIV. Barley and Rye.
XLV. Grasses.
XLVI. Grasses.
XLVII. Clovers.
XLVIII. Pastures.
XLIX. Silage.
L. Forage Crops.
LI. Potatoes.
LII. Potatoes.
LIII. Root Crops: Mangels, Beets, Turnips.
LIV. Sugar Plants: Sugar Beets.
LV. Sugar Plants: Cane, Sorghum, etc.
LVI. Fiber Plants: Cotton.
LVII. Fiber Plants: Cotton.

Chapter LVIII. Fiber Plants: Flax, Hemp, Jute, Ramie, Sisal, etc.
LIX. Stimulants: Tobacco, Tea, Coffee.
LX. Medicinal and Aromatic Plants.
LXI. Miscellaneous Plants: Buckwheat, Broom Corn, Peanuts, Hops, Canaigre, etc.

[The order of discussion of the different crops will be the same as in the case of wheat. The details to be given for each crop will vary with the importance of the crop in any region.]

PRACTICUMS OR LABORATORY WORK IN AGRONOMY.

(The practicums are intended to cover 33 laboratory periods, i. e., 66 hours.)

1. Determination of specific gravity of soils.
2. Determination of volume weight of soils.
3. The power of retaining moisture in the soil in its highest degree of looseness.
4. The power of retaining moisture in the soil when compacted.
5. Rate of percolation of water thru soils.
6. Rate of percolation of air thru soils.
7. Effect of mulches upon evaporation of water from soils.
8. Behavior of soils toward gases.
9. Capillary attraction in soils.
10. Determination of cohesion in soils.
11. Mechanical analysis of soils.
12. Do.
13. Study of root systems of principal crops.
14. Do.
15. Do.
16. Study of varieties of corn in field.
17. Scoring ears of corn.
18. Study of effect of fertilizers on one or more crops in fall.
19. Study of effect of fertilizers on one or more crops in early spring.
20. Study of effect of fertilizers on one or more crops near harvest.
21. Study of varieties of wheat in sheaf and by sample.
22. Do.
23. Study of varieties of wheat in field.
24. Study of varieties of oats or other grain in sheaf and by sample.
25. Study of varieties of oats or other grain in field.
26. Study of varieties of potatoes by sample.
27. Study of varieties of potatoes in field.
28. Study of varieties of grasses and forage crops in field in fall.
29. Study of varieties of grasses and forage crops in field in early spring.
30. Study of varieties of grasses and forage crops near harvest in field.
31. Study of varieties of grasses and forage crops by sample and preparation of abstracts of station experiments on climatic and soil conditions and upon quality and yield.
32. Do.
33. Do.

SYLLABUS OF COURSE IN ZOOTECHNY.

Zootechny.—Theory and practise of the production of animals useful to man. Broadly speaking, zootechny would also include the diseases of such animals, but as this is a large subject in itself and would most naturally be taught in a separate department under the head of veterinary science (as is proposed in the course in agriculture outlined by this committee, see page 3), it seems best to confine zootechny as a division of technical agriculture to that which relates to the production of the normal useful animal.

- **The animal**
  - Anatomy (details to be taught under veterinary science).
  - Physiology (details to be taught under general physiology).
  - Management[a]
    - Animal types.
    - Breeding.
    - Feeding.
    - Hygiene.
    - Systems of management.
- **Animal production**
  - In agriculture has for its object the securing and growing of animals which in themselves or in their products are best suited to the uses of man.
- **Classification of useful animals.** (This is only a partial classification and the animals named under each class will vary according to circumstances.)
  - Mammals
    - Herbivora
      - Cattle.
      - Sheep.
      - Goats.
      - Swine.
      - Camels.
      - Horses.
      - Asses.
      - Mules.
      - Rabbits.
      - Hares.
    - Carnivora
      - Dog.
      - Cat.
  - Birds
    - Fowls.
    - Ducks.
    - Geese.
    - Pigeons.
    - Turkeys.
    - Pheasants.
    - Ostriches.
  - Fishes
    - Salmon.
    - Trout.
    - Carp.
  - Insects
    - Bees.
    - Silkworms.
  - Miscellaneous
    - Frogs.
    - Oysters.
    - Snails.
- **1. Principles governing the choice and breeding of animals.**
  - Animal types
    - Conformation.
    - Animal mechanism.
    - Methods of scoring.
  - Breeding
    - Heredity
      - Normal characters.
      - Abnormal characters.
      - Atavism.
    - Variation
      - Causes.
      - Laws.
    - Selection
      - According to merit.
      - According to relationship (pedigrees)
        - In breeding.
        - Cross breeding.
    - Prenatal influence
      - Sire and dam.
      - Maternal impression.
      - Previous impregnation.
    - Fecundity.
    - Sex.

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[a] Under the head of animal production we need most largely to consider those topics which relate to man's agency in obtaining the results with animals desired in practical agriculture, and which are conveniently grouped under the general topic—management.

- **2. Types and breeds of different kinds of animals.**
  - Class
    - Place of classification.
    - Anatomy.
    - Physiology.
    - Zoological relation.
    - Domestication.
    - Varieties or breeds
      - Classification.
      - Characters.
      - Development.
      - Distribution.
      - Breeders' organizations.
    - Stock judging (practise in scoring).
    - Breeding (relation of principles to practise).
- **3. Principles of feeding.**
  - Foods
    - Nature (as related to the animal organism).
    - Constituents
      - Refuse.
      - Edible portion
        - Water.
        - Nutrients
          - Protein.
          - Fats.
          - Carbohydrates.
          - Mineral matters. (ash.)
    - Functions.
    - Classes
      - Coarse fodders.
      - Concentrated feeding stuffs.
    - Composition.
    - Digestibility.
    - Effects
      - On condition of animal.
      - On product.
    - Manurial value.
  - Food requirements (of different animals for different purposes).
  - Feeding standards.
  - Rations
    - Compounding.
    - Methods of use.
- **4. Practise in feeding different kinds of animals.**
  - Food requirements (feeding standards)
    - For maintenance.
    - For growth.
    - For meat, fattening.
    - For wool and hair.
    - For milk.
    - For work.
  - Rations
    - Compounding.
    - Methods of use.
    - Economy.
  - Systems of feeding.
  - Effect of food
    - On condition of animal.
    - On product.

- **5. Principles of hygiene and management.**
  - Hygiene
    - Air supply.
    - Water supply.
    - Exercise.
    - Cleanliness.
    - Comfort.
    - Protection; e. g., against heat, cold, accident, escape.
    - Modification of body
      - Dehorning.
      - Docking.
      - Shearing.
      - Castration.
      - Spaying.
  - Systems of management
    - For single animals
    - For groups of animals (herds, flocks, etc.)
      - Under different conditions; e. g., in freedom, in inclosures, or in buildings.
- **6. Practise in the management of different kinds of animals.**
  - Hygiene
    - Air supply.
    - Water supply.
    - Exercise.
    - Cleanliness.
    - Protection.
    - Modification of body.
  - Systems of management
    - For single animals.
    - For groups of animals.
  - Care of product.
  - Extent of production.
  - Marketing.

After considerable discussion the committee decided upon the above order of topics as being probably the one most practical for adoption in American agricultural colleges. There are, however, some important considerations which may be urged in favor of teaching the principles of the different branches of zootechny together before taking up the application of any of them to different kinds of animals. In case that seemed best, the general topics in this syllabus might be rearranged in the following order: 1, 3, 5, 2, 4, 6. The fundamental difference between the two schedules is indicated in the following summary:

SYLLABUS 1.

1. Principles governing the choice and breeding of animals.
2. Types and breeds of different kinds of animals.
3. Principles of feeding.
4. Practise of feeding different kinds of animals.
5. Principles of hygiene and management.
6. Practise in the management of different kinds of animals.

SYLLABUS 2.

- Principles
  - Animal types.
  - Breeding.
  - Feeding.
  - Hygiene.
  - Systems of management.

Application of principles to different kinds of animals; e. g.:

- Horses
  - Stock judging.
  - Breeding.
  - Feeding.
  - Hygiene.
  - Systems of management.

SYLLABUS OF COURSE IN AGROTECHNY.

In its broadest sense agrotechny would include a wide range of subjects, such as the making of butter, cheese, sugar, starch, vegetable and animal oils, vinegar, concentrated foods and feeding stuffs, canned goods, malt and alcoholic liquors, textiles, and leather. For the purposes of a general college course in agriculture in the United States it will ordinarily include only dairying, with brief treatment of other industries locally important, e. g., sugar in Louisiana, Nebraska, and Vermont; olive oil in California; cotton goods in South Carolina, Georgia, and Mississippi; flour in Minnesota; meat products in Illinois, and corn products in Kansas. In the following outline, therefore, provision is made for such brief introductory consideration of the subject as a whole, and more detailed treatment of dairying, as may be reasonably given in the time (72 hours) assigned to agrotechny in the general course in agriculture. It is not intended in this syllabus to cover the requirements of special schools and courses in dairying, sugar making, etc. This matter requires special attention and may be taken up by the committee at some future time.

GENERAL OUTLINE OF TOPICS IN AGROTECHNY.

- **Definition**
  - Agrotechny is the theory and practise of the conversion of raw materials produced by agriculture into manufactured articles for use in commerce and the arts.
- **The raw material.**
  - Source.
  - Standard
    - Properties.
    - Departures from standard
      - Natural.
      - Artificial
    - Determination.
  - Handling.
  - Uses.
- **Manufacture**
  - Processes.
  - Equipment.
- **The product**
  - Description.
  - Standard
    - Properties.
    - Departures from standard.
    - Determination.
  - Handling.
  - Marketing.
  - Uses.

DAIRYING.

- **The raw material—Milk.**
  - Source
    - Kind of animal.
    - Physiology of secretion.
    - Milking
      - Frequency.
      - Regularity.
      - Method
        - By hand.
        - By machine

- **The raw material—Milk**—Continued.
  - Standard
    - Properties
      - Physical.
      - Chemical.
      - Biological.
    - Departures from standard
      - Natural
        - Due to animal
          - Lactation.
          - Food.
          - Environment.
        - Due to micro-organisms.
      - Artificial
        - Impurities.
        - Adulteration.
    - Determination
      - For specific gravity.
      - For fat.
      - For organisms.
      - For impurities.
      - For adulteration.
  - Handling
    - Cleanliness
      - Stables.
      - Cows.
      - Attendants.
      - Vessels.
    - Control of fermentation
      - Prevention of infection.
      - Refrigeration.
      - Aeration.
      - Pasteurization.
      - Sterilization.
  - Uses[a]
    - For consumption as milk or cream.
    - For condensed milk or cream.
    - For butter.
    - For cheese.
    - For artificial beverages.
    - For sugar.
    - For casein preparations.
- **Milk and cream for consumption.**
  - Preparation for sale
    - Removal of sediment
      - Straining.
      - Centrifugal separation.
    - Standardizing.
    - Creaming as affected by
      - Pasteurization.
      - Centrifugal separation.
    - Packages
      - Cans.
      - Bottles.
    - Bottling
      - Washing.
      - Sterilizing.
      - Filling.
      - Capping.
  - Delivery and sale
    - Wagons.
    - Tickets.
    - Accounts.

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[a] In this syllabus only the following uses of milk will be considered in detail: (1) For consumption; (2) for butter, and (3) for cheese.

Butter making (Manufacture).

- Processes
  - Theory.
  - Creaming
    - Gravity
      - Shallow pans.
      - Deep cans
        - Shot-gun cans.
        - "Cooley" system.
        - Dilution separators.
    - Centrifugal (separator)
      - History.
      - Theory.
      - Styles and types.
      - Operation
        - Setting.
        - Speeding.
        - Inflow.
        - Regulation of cream.
  - Ripening
    - Purpose.
    - Temperature
      - Cooling after separating.
      - Reheating.
    - Starters
      - Natural
        - Sour cream.
        - Sour milk.
        - Buttermilk.
      - Artificial
        - Preparation.
        - Propagation.
        - Use.
    - Determination of ripeness
      - Appearance.
      - Consistency.
      - Acidity
        - Taste.
        - Acid tests.
  - Churning
    - Theory.
    - Temperature.
    - Breaking.
    - Difficult churning.
    - Churns
      - Form.
      - Size.
      - Speed.
  - Finishing
    - Removal of buttermilk.
    - Addition of salt
      - Brine.
      - Dry.
    - Working
      - Purpose.
      - Amount necessary.
      - Temperature.
  - Packing
    - Prints
      - Apparatus.
      - Covers.
    - Tubs
      - Sizes.
      - Materials.
    - Stone jars.
    - Paper packages.
- Equipment
  - Farm dairy
  - Creamery
    - Location.
    - Construction.
    - Arrangement.
    - Equipment.
    - Management.

- **Butter** (The product.)
  - Description.
  - Standard
    - Properties
      - Physical
        - Texture.
        - Color.
        - Finish.
      - Chemical.
      - Biological
        - Flavor.
    - Departures from standard.
    - Determination.
  - Handling.
  - Marketing.
  - Uses.
- **Cheese making.** (Manufacture.)
  - Processes
    - Theory.
    - Kinds of cheese
      - Cheddar.
      - Swiss.
      - Brick.
      - Limburger.
      - Foreign varieties (Roquefort, etc.).
    - Preparation of milk.
    - Separation and manipulation of curd
      - Rennet
        - Source.
        - Preparation.
        - Action.
      - Setting.
      - Cutting.
      - Heating.
      - Cheddaring.
      - Grinding.
    - Salting.
    - Pressing.
    - Curing.
    - Packing.
  - Equipment
    - Factory
    - Farm dairy
      - Location.
      - Construction.
      - Arrangement.
      - Apparatus.
      - Management.
- **Cheese** (The product.)
  - Description.
  - Standard
    - Properties
      - Physical
        - Texture.
        - Color.
        - Finish.
      - Chemical.
      - Biological
        - Flavor.
    - Departures from standard.
    - Determination.
  - Handling.
  - Marketing.
  - Uses.

SYLLABUS OF COURSE IN RURAL ENGINEERING.

In its most comprehensive sense rural engineering includes all the branches of civil and mechanical engineering relating to the locating, arranging, and equipping of farms, and the construction and operation of farm implements and machinery. A prerequisite to thoro knowledge of rural engineering would thus be a general course in civil and mechanical engineering. As students in an agricultural course in our colleges can not be expected to have this preliminary training (except some knowledge of surveying and the use of surveying instruments, which is quite essential), it will be necessary to confine the course in rural engineering as a part of the general course in agriculture to the more elementary matters which will be understood by such students, and which have a direct, practical bearing on farm management.

There is need of the establishment of thoro courses in rural engineering as specialties in some of our higher institutions, in order that well-trained rural engineers may be produced to act as leaders in the advancement of engineering enterprises for the benefit of agriculture.

- **Definition** .. Rural engineering is the science and art of laying out farms, designing and constructing farm buildings and works, and making and using farm implements and machinery.
- **Laying out the farm.**
  - Principles of selection.
  - Survey.
  - Location of buildings and works (drains, irrigation ditches, wells, and roads).
  - Division into fields and yards.
  - Map of farm.
- **Construction of buildings and works**
  - Buildings ....
    - Principles of construction.
    - Materials.
    - Classification[a] .....
      - House.
      - Barn.
      - Piggery.
      - Poultry house.
      - Tool house.
      - Creamery.
      - Fences.
    - Purpose.
    - Plans.
    - Methods of building.
    - Cost.
  - Water system ....
    - Springs.
    - Wells.
    - Reservoirs.
    - Pumps and other water lifts.
    - Conduits.
    - Tanks.
    - Plumbing.

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[a] The list given is only illustrative. The buildings to be discust in this course would vary with the region, system of farming, etc.

- **Construction, etc.—Continued.**
  - Irrigation system
    - Theory.
    - Water supply (sources, character, and means of obtaining).
    - Works
      - Reservoirs.
      - Canals.
      - Laterals and ditches.
      - Appliances for measurement and division of water.
    - Methods of application.
  - Drains
    - Removal of surface water (drainage of swamps, etc.).
    - Soil drainage
      - Theory.
      - Open drains.
      - Covered drains (including stone, brush, tile, etc.).
  - Sewage system.
  - Roads
    - Location.
    - Materials.
    - Construction.
    - Maintenance.
- **Construction and use of farm machinery.**
  - Principles of mechanics as applied to farm machinery.
  - Classification
    - Power machines
      - Steam.
      - Gasoline.
      - Water.
      - Wind.
      - Horse.
      - Man.
    - Plows.
    - Surface-working machines.
    - Seeding machines.
    - Harvesting machines.
    - Food-preparing machines.
    - Farm vehicles.
    - Small implements.
  - Structure.
  - Operation
    - Principles.
    - Practise.
  - Repairing.

SYLLABUS OF COURSE IN RURAL ECONOMICS.

- **Definition**
  - Rural economics treats of agriculture as a means for the production, preservation, and distribution of wealth by the use of land for the growing of plants and animals. It may include the development of agriculture as a business (history of agriculture), as well as the facts and principles of farm management under present conditions.
- **History of agriculture.**
  - Development of different forms.
    - Grazing.
    - Plant industry.
    - Mixt husbandry.
    - Special farming.
  - Agriculture in different periods (with special reference to land tenure, equipment, labor system, prominent products, social and financial condition of farmers).
    - I. Prior to 500 B. C. (Egyptian.)
    - II. 500 B. C. to 500 A. D. (Grecian and Roman.)
    - III. 500 A. D. to 1500 A. D. (Western Europe—feudal system.)
    - IV. 1500 A. D. to 1800 A. D. (Especially in Great Britain.)
    - V. 1800 A. D. to 1900 A. D. (Especially in United States.)

- **Farm management.**
  - Capital
    - Land
      - Value as determined by location, suitability, etc.
      - Purchase, rental, and sale.
      - Cost of maintenance.
        - Taxes.
        - Rents.
        - Interest.
      - Legal requirements.
    - Equipment
      - Nature (as related to particular kinds of farming).
        - Buildings.
        - Fences, roads, wells, drains.
        - Implements.
        - Live stock.
      - Value.
      - Cost of maintenance.
        - Taxes.
        - Insurance.
        - Repairs.
        - Feeding.
      - Legal requirements.
  - Labor
    - Systems (wage, share, tenant).
    - Contracts, including methods of payment.
    - Cost, as affected by labor supply, use of machinery, nature of work, etc.
    - Management.
  - Production
    - Methods and cost (with reference to different systems of farming).
  - Marketing
    - Preparation for market.
    - Choice of market.
    - Transportation.
    - Method and cost of sale.
    - Legal requirements, e. g., weights, measures, packages, commissions, inspection.
  - Records and accounts
    - Crop records.
    - Feed and milk records.
    - Breeding records.
    - Inventories.
    - Bookkeeping.

GENERAL CONSIDERATIONS.

Some of the general considerations on which the work of the committee has been based are as follows:

(1) The arrangement of the topics to be taught under each head in a logical and pedagogical order has been deemed of fundamental importance. Unless the facts and principles taught under the general head of agriculture can be reduced to a pedagogical system and correlation it will be difficult to maintain for agriculture that position in our educational scheme to which we believe it is fairly entitled. The syllabus of the committee should therefore be judged primarily with reference to its conformation to sound pedagogical principles. The danger is that too much stress will be laid on the present and, as we sincerely hope, temporary exigencies of particular colleges as affecting the scope and order of their course in agriculture. While the committee desires

to have the outcome of its work practical as well as correctly theoretical, it believes that it is to consider first, what is the most perfect arrangement of an agricultural course from a pedagogical standpoint, and afterward how such a course may be wisely adapted to the prudential necessities of existing institutions.

Again, we ask that in the discussion of this subject the order and method of treatment followed in certain widely used text-books and manuals may not be deemed so firmly established as correct as to preclude further inquiry in this direction. It is natural and right that we should have reverence for the standard authorities of our school days and college lecture rooms, but it is an easy step from this to confound creed with revelation. And at this stage in the progress of agricultural education we believe that a most necessary thing is to submit existing manuals to rigid examination with reference to their pedagogical merits. It may be a difficult thing for some of us to appreciate the superiority of any revised version of agricultural scriptures, but unless we bring to this discussion an open mind and willingness to examine the subject from different points of view, it will be of little use to enter upon it.

(2) The committee has deemed it wisest to plan the course in different branches of agriculture without special reference to the titles of the teachers who might be called upon to teach the different topics included therein. In our view it makes little difference whether some unfortunate "professor of agriculture" is compelled to bear the heavy burden of sending the student thru the entire course or whether numerous specialists give their combined energies to the task. Thus different parts of agronomy might be taught by the chemist, physicist, fertilizer expert, botanist, agrostologist, plant culturist, etc., or zootechny by the physiologist, veterinarian, expert breeder, dairy farmer, sheep husbandman, etc.

Again, the amount of detail to be taught under different topics will naturally vary with the previous training of the pupil in scientific subjects and with the provision made in other courses for instruction in subjects related to agriculture. Thus, if the student has had or is to have a thoro course in geology he will not need to pay much attention to the topics included under "origin of soils" in the course in agronomy; or if soil physics is a separate department of instruction, matters relating to the properties, moisture, etc., of soils need not be much dwelt upon in the course in agronomy; or the discussion of fertilizers may be largely turned over to the course in agricultural chemistry.

But, on the other hand, we are inclined strongly to contend that in the courses in agriculture a comprehensive scheme of instruction should be adopted, and that all the topics should be included which are necessary to a clear understanding of the proper relations of the different parts of the subject. We hold that there is such a thing as a science of agriculture, secondary and complex in its nature, and deriving its facts and principles very largely, if not wholly, from other more primary sciences, but after all to be differentiated as a distinct entity from the other sciences, however dependent it may be on them for its materials. And we urge that one radical defect of agricultural instruction thus far has been that so much of the teaching of agricultural subjects has been done in a disjointed way by experts in different branches of science. The student has therefore often not had the subject of agriculture presented to him as a connected whole with related parts, and has for this reason failed to appreciate that there was any such thing as a science of agriculture, or has not learned to make any useful application of what he has learned in various sciences to either the theory or the practise of agriculture. Thus, we believe, for example, that however much the student may have learned or will learn about the physiology of plants, or the physics of soils, or the chemistry of fertilizers, at some period in his agricultural course he should have all these subjects grouped together in a course in agronomy, and there learn their relation to each other and to the methods employed in the production of crops in actual agricultural practise. If the student has had considerable previous training in vegetable physiology, soil physics, and agricultural chemistry, the wise teacher will take advantage of this by quizzes or a system of references, and rejoice in the opportunity this gives him to enter more deeply into complex topics of agricultural science and practise involving a combination of the preliminary sciences; or if a more complete course in these other sciences awaits the student, the teacher of any branch of agriculture should confine himself to such an outline as will show the necessary relation of these sciences to the science and practise of agriculture, and deeply impress upon the student the great desirability of his improving every opportunity for wider scientific training if he would most thoroly comprehend the intricacies and subtleties of the science of agriculture. In our view, the teaching of any secondary science, such as meteorology, geography, medicine, or agriculture, involves a pedagogical scheme which brings together into a consistent whole whatever more or less disconnected facts and principles of other sciences related to the composite science have already been learned by the student, and which at the same time leads the student to desire to broaden and deepen his acquaintance with the basal sciences, however long he may study the composite one. One of the great pedagogical advantages, as it seems to us, which such a science as that of agriculture enjoys is that it necessitates a broadly related knowledge of a number of basal sciences. If generally and efficiently taught in our colleges it will do much to counteract the pernicious influences of a narrow specialism which has in recent years been fostered by a false eclecticism. This requires, however, that agriculture in its scientific and practical aspects shall be treated as a distinct entity, and not be hopelessly dismembered in the scheme of college instruction.

(3) While we have held somewhat rigidly to the foregoing pedagogical considerations, we have, nevertheless, attempted to make a scheme sufficiently elastic to readily adapt itself to the requirements of institutions having considerable variations in the grade of agricultural instruction and differing widely in the number of teachers and of courses in scientific and other subjects. For this reason we have refrained from making definite suggestions regarding the amount of time to be given to different topics, and have called attention to the fact that the number of different kinds of plants and animals which it will be well to consider in detail will properly vary with circumstances. The kind of agriculture in the environment of any institution will naturally suggest the various limitations of this branch of the agricultural course, but aside from this such conditions as lack of teachers or equipment will largely determine the extension or restriction of these topics.

THE RELATION OF THE NATURAL SCIENCES TO AGRICULTURE IN A FOUR-YEAR COLLEGE COURSE.

The more definite formulation of courses of instruction in agriculture, the division of these courses according to the several branches of the science of agriculture, and the consequent specialization of the courses due to the employment of an increased force of experts in various agricultural subjects, have already led to a considerable reorganization of faculties and courses in our agricultural colleges. This movement is continuing and will further develop with the increase of the resources and equipment of the agricultural departments of these institutions. One effect of this movement has been to change the relation of the natural sciences to agriculture in the scheme of instruction in the agricultural colleges. As long as agriculture was taught almost wholly on a practical basis and without much regard to its pedagogical formulation, the teachers of the natural sciences were called upon not only to develop the relations of these sciences to agriculture in their courses of instruction, but to give instruction in strictly agricultural subjects, and this was done to a considerable extent, especially in chemistry and botany. Out of this grew a series of text-books and manuals in which the general principles of these sciences were more or less extensively combined with statements of their relations to the theory and practise of agriculture. Thus we have books on agricultural chemistry, agricultural botany, agricultural physics, etc. The preparation of such books was a very useful work. They helped to turn the attention of scientists to the importance of the problems of agriculture and thus led to the further investigation of these problems;

they brought together many facts and principles out of which in large measure the science of agriculture itself is now being constructed. But this method of procedure, as we can now see, had also some unfortunate results from which we are seeking to escape thru the more thoro formulation of the science of agriculture and of courses based thereon, and the readjustment of the courses in the natural sciences to meet this new condition of agricultural pedagogy.

One result of the prolonged study of the relations of science to agriculture was to lead both teacher and student too far afield in the pursuit of problems which, tho important scientifically and even economically, had too remote connection with agriculture itself to make it worth while for the student whose aim was to be a master of the theory and practise of agriculture to follow after them. Thus, for example, agricultural chemistry developed a system of analysis of fertilizers, feeding stuffs, and adulterated products which, in the minds of many teachers, came to be so prominent a part of this branch of chemistry that it often assumed an undue importance in the general agricultural courses in our colleges. Now we shall always need expert analysts of fertilizers and feeding stuffs, and special courses for the training of those experts should be offered in our agricultural colleges. But these should be clearly differentiated from the courses intended to lay the foundations for the scientific study of agriculture. Under the old system the emphasis was often laid so much on analytical work that the colleges produced many analysts and but few agricultural experts. So in botany it is easily possible, for example, to lay so much stress on studies of fungi and bacteria, or grasses, that the students are led to strive to become experts in vegetable pathology or agrostology. It is true we need many more such experts, but, nevertheless, it should not be the object of botanical studies underlying the general course in agriculture to aim at the training of pathological experts or agrostologists or any other kind of botanical experts. While botanical experts and agricultural experts may for a time profitably study botany together their paths should soon diverge, and this must be kept in mind by teachers of botany.

Another unfortunate result of the old arrangement of courses in our agricultural colleges was that the study of the general principles and outlines of the various natural sciences was often unwisely abridged in order to give more attention to their economic applications. This has perhaps not been so much the fault of the science teachers as of the managers of the agricultural colleges. The attempt to create a very practical atmosphere in these institutions has often led to great disregard of established pedagogical principles in the teaching of the complex subjects relating to agriculture and other arts. Nothing is more firmly established in pedagogical science than the principle that, before proceeding to the study of complex problems, the pupil should become acquainted with the elementary facts and principles involved in the solution of these problems. It is also very generally agreed that an outline study of a general subject which will enable the pupil to have some comprehension of the subject as a whole and the relations of its different parts should precede detailed study of special topics included in this general subject. Thus it is best both practically and pedagogically that the boy in the graded schools should be taught an outline of the history of the United States. He will thus acquire a certain amount of information which will be useful to him if he goes out into life from the graded school, and he will also have laid the best foundation for such special studies of United States history as he may have opportunity to pursue in higher courses of instruction. In like manner in the natural sciences there should be a sufficient period of general study before special topics are taken up, and the abridgment of this preliminary course throws the future course of the student out of pedagogical balance.

The general readjustments of science teaching which are demanded by the present development of our agricultural colleges are, therefore, first, the more thoro teaching of the foundations of the natural sciences; secondly, the clearer differentiation of the courses in natural science associated with the courses in agriculture from those which are intended for the training of experts in various economic specialties related to agriculture, and, thirdly, the separation from the science courses of those subjects which may be more appropriately taught by the instructors in the various branches of agriculture itself. From the nature of the case it is obvious that the details of these readjustments can be worked out only as the result of many experimental efforts and long discussion of the practical and pedagogical points involved. The evolutionary forces which are to result in the elaboration of more perfect and satisfactory courses of instruction in agriculture are already at work in our agricultural institutions and they will continue to work for an indefinite period. It has seemed, however, to your committee that at this juncture it would be helpful to call attention to some of the general factors of this evolution and even to suggest a somewhat definite mode of procedure to secure the sought-for ends. In this, as in other lines of its work, the committee has assumed that it would be more useful to present a definite scheme rather than general suggestions. This is done with the understanding, as heretofore, that the committee is not seeking to establish dogmas or write prescriptions, but only to furnish a definite basis for discussion. It is the more encouraged to continue efforts in this line because it is convinced that, as the result of its previous efforts, the movement for the betterment of courses of instruction in our agricultural colleges has been materially aided, tho no institution has adopted in detail the program laid down in the reports of this committee.

As the basis of our presentation of a scheme of science teaching for a four-year college course in agriculture, we take (1) the standard entrance requirements laid down in the report of your committee on entrance requirements as given on page 1; (2) the general outline of the college course as made by that committee and our committee as given on page 2; and (3) the syllabi of courses in the different branches of agriculture as laid down in the reports of this committee. (See pages 5, 9, 13, 17.)

The standard entrance requirement scheme has been taken, rather than the abridged scheme presented by the entrance requirement committee, because in our judgment there can be no satisfactory arrangement of college courses in agriculture until the students admitted to the college courses have had suitable preparation in secondary schools. Within the past few years there has been a wonderful development of the high schools in all parts of our country and there has been set on foot a movement for the establishment of secondary schools and courses especially adapted to the requirements of our agricultural communities. The agricultural colleges should encourage this development of secondary education in many ways. But they should do so especially by differentiating their college courses more distinctly from secondary courses, and putting their college courses on a sufficiently high basis to make the bachelor's degree from an agricultural college represent an education of as high a grade as a bachelor's degree from any other college. For this purpose the standard entrance requirement scheme referred to above is none too high. This provides for at least a year's instruction in some natural science. It is believed by your committee that ordinarily an elementary course in physics or chemistry in the high school will best lay the foundation for further science study. In the scheme herewith presented we selected physics as the science to be taught in the high school as the preliminary to science study in the college course in agriculture.

In the general scheme of the four-year college course in agriculture presented herewith we have first provided for courses in general physics and chemistry on the assumption that these would naturally precede the study of plants and animals, whether in a general way under the head of botany, physiology, or zoology, or in a special way under the different branches of agriculture. Some knowledge of physics and chemistry is also essential to a proper understanding of even the elements of meteorology and geology, as provided for in this course. Botany has been so placed as to run along with agronomy, and physiology and zoology with the more scientific presentation of zootechny.

While we believe it would be well for the agricultural student in his undergraduate work to take all of the subjects included in the scheme as here outlined, yet we have recognized the demand for an earlier specialization of agricultural work by so arranging the course that in senior year at least some studies may be substituted for those laid down in our scheme. For example, if the student is aiming to be a plant expert he may omit veterinary science and take more of applied botany or horticulture, or specialize in agronomy as far as additional courses in these subjects are offered in the institution he attends. In a similar way the student devoted to animal industry may substitute special studies along this line for the horticulture and forestry.

Agricultural experts can not, however, expect that any properly adjusted undergraduate course will fully meet their needs for training along their chosen lines. Persons who expect to enter positions in our Department of Agriculture, experiment stations, or agricultural colleges should attain at least the master's degree. And erelong the doctor's degree will be a prerequisite to entrance on the career of agricultural teacher or investigator in our colleges and universities and the National Department of Agriculture.

In outlining the courses in the various sciences the purpose has been to indicate, in a general way, the topics which may properly be included in such courses, taking into account the time limitations and what will be taught under the head of agriculture. The arrangement of these topics and the emphasis to be laid on each of them will, of course, vary with the teacher as well as the equipment and other conditions existing in particular institutions. Our effort has been chiefly to so present this matter as to indicate how the science teaching may be differentiated from and at the same time related to the teaching of agriculture in a college course.

In arranging this scheme the committee has had the assistance of the expert officers of the Office of Experiment Stations and of Prof. G. P. Merrill, the geologist of the Smithsonian Institution. Text-books and specialists in a number of different lines have also been consulted. As the result of a conference with Mr. A. F. Woods, assistant chief of the Bureau of Plant Industry, who is chairman of a committee appointed by the section of botany and horticulture of this association to formulate a scheme for courses in botany, it was ascertained that after an independent study of this matter that committee had reached substantially the same conclusions as had our committee, as far as the lines of our work coincided, and that both committees were in general accord with the scheme proposed by a committee of the Society for Plant Morphology and Physiology. Special attention is therefore invited to the report presented by Mr. Woods to the section on botany and horticulture.

The standard series of entrance requirements referred to above is as follows:

(1) Physical geography.
(2) United States history.
(3) Arithmetic, including the metric system.

(4) Algebra, to quadratics.

(5) English grammar and composition, together with the English requirements of the New England Association of Colleges and Preparatory Schools.

(6) Plane geometry.

(7) One foreign language.

(8) One of the natural sciences.

(9) Ancient, general, or English history.

The general relation of the natural-science courses to those in agriculture and other subjects may be seen in the following outline of the agricultural course in college as laid down in a previous report of this committee:

Agricultural course in college.[a]

Freshmen.		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Physics..........	150	Agriculture: Zootech ...60 Agron 90	150	Agriculture: Agron .... 50 Zootech ..100	150	Agriculture: Dairying ..70 Farm mechanics..60 Rural economics ..60	190
Chemistry.......	150	Meteorology....	60	Geology	120	Veterinary medicine.....	180
Geometry and trigonometry..	155	Agricultural chemistry	180	Botany.........	60	Horticulture and forestry..	180
English	120	Botany.........	120	Physiology	180	History and political economy	190
Modern language	180	English	80	Zoology	120	Ethics..........	40
		Modern language	100	Psychology.....	60		
		Drawing........	60	Modern language.........	60		
	755		750		750		780

[a] A general outline of this course, without reference to its division according to years, is given on page 2. The number of hours assigned to each subject includes the time given to laboratory exercises, each of which would occupy two hours. Thus, for example, 150 hours of physics may be divided into 60 lectures or recitations, and 45 (=90 hours) laboratory exercises. Our committee has not attempted to say how the time should be divided between lectures or recitations and laboratory exercises, but presupposes that a reasonable number of laboratory exercises or practicums will be given in all the science courses.

The arrangement of the college course here suggested proceeds on the assumption that it is best for the student to devote his time largely during the first two years to language, mathematics, and the fundamental sciences, physics, chemistry, and botany. He will thus be prepared for a better understanding of the more complex sciences of agriculture, zoology, animal physiology, and veterinary medicine in the second half of his course.

The course in agriculture has been arranged with reference to taking up first in sophomore year some of the simpler topics in zootechny, such as stock judging and types of breeds, which do not require scientific knowledge but are well calculated to arouse the interest of the student in agricultural subjects. Agronomy may then be taken up systematically and run along with the study of meteorology, agricultural chemistry, and botany, and the more scientific study of zootechny may be parallel with the study of physiology and zoology. In senior year a considerable number of electives could be offered, one or more of which might be substituted for veterinary medicine, horticulture and forestry, or history and political economy, so as to enable the student to specialize in agronomy, horticulture, zootechny, dairying, farm mechanics, vegetable pathology, entomology, etc. In general, however, it is believed that the course as here outlined will be satisfactory as providing a liberal education, including systematic study of the theory and practise of agriculture, and as a good foundation for specialization in agriculture and the sciences related thereto in postgraduate courses.

COURSES IN THE NATURAL SCIENCES.

PHYSICS—PREPARATORY COURSE.

General laws and principles of—
- Dynamics of solids, liquids, and gases.
- Heat.
- Electricity and magnetism.
- Sound.
- Light.

PHYSICS—COLLEGE COURSE—150 HOURS.

General constitution and properties of matter.

Dynamics, or the general laws of force and the relations existing between force, mass, and velocity as applied to	Solids (mechanics).	
	Liquids (hydrostatics).	
	Gases (pneumatics).	
Heat	Measurement of temperature (thermometry).	
	Expansion (solids, liquids, gases).	
	Measurement of quantity of heat (calorimetry, specific heat).	
	Latent heat.	
	Fusion and solidification.	
	Evaporation and condensation.	
	Conduction.	
	Radiation.	
	Thermodynamics.	
	Relation of temperature to movements of the atmosphere.	
Electricity and magnetism.	General theories and laws.	
	Sources and production.	
	Measurement.	
	Atmospheric electricity.	
	Applications.	
Sound and light	Sound—production and propagation.	
	Light	Propagation.
		Reflection.
		Refraction.
		Polarization.
		Applications—lenses and optical instruments.
	Color.	

GENERAL CHEMISTRY—150 HOURS.

- **Properties of elements and chemical reactions.**
- **Inorganic preparations.**
- **Introduction to qualitative analysis.**
  - Blowpipe analysis.
  - Separation of groups.
- **Introduction to organic chemistry.**

AGRICULTURAL CHEMISTRY—180 HOURS.

- **General introduction and review.**
  - Composition and properties of matter.
  - Properties and laws of combination of elements and simpler compounds.
  - Laboratory manipulations.
  - Classification of elements, equations, formulas, etc.
- **Chemistry of**
  - Air and water.
  - Soils and fertilizers.
  - Plant growth and products.
  - Animal life
    - Foods.
    - Nutrition.
    - Animal body and products.
  - Dairying.
- **Introduction to analytical methods.**

BOTANY—180 HOURS.[a]

The accompanying outline course for botany in the agricultural colleges is based very largely upon the standard elementary course recommended for adoption by the Society for Plant Morphology and Physiology and embraces one year's work, the lectures and laboratory work required being about 180 hours. The various topics and sequence need not be strictly followed, and in many cases it will be found advisable to transfer subjects from one group to another in the sequence of teaching. Either group may be condensed, or each may be extended to cover a year's work. If 120 hours are given in the second year and 60 hours in the third year, the adjustment can be made to suit the convenience of the instructor and the facilities for instruction. Instruction in taxonomy is not provided, since the use of the manual, while desirable in itself, is not essential for an elementary course in botany. In Botany II it is recommended that the earlier groups of plants be past over rapidly, particular attention being given to their economic features, and that progressively more time be given to the higher and more conspicuous forms. The course as a whole may be given in about 80 hours of lectures or recitations and 100 hours of practicums.

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[a] The time allowance for this course might with advantage be extended to 240 hours by taking 60 hours from physiology, which has been given a relatively liberal time allowance.

BOTANY I.—GENERAL PRINCIPLES.

- **Anatomy and Morphology.**
  - The seed
    - Types.
    - Structures.
    - Homologous parts.
    - Food supply.
    - Germination.
  - The shoot
    - Gross anatomy.
    - Phyllotaxy.
    - Buds
      - Common forms.
      - Winter forms.
    - Tissues
      - Structure.
      - Distribution.
    - Specialized forms of stems, leaves, etc.
    - Growth, annual.
    - Shedding of bark, leaves, etc.
  - The root
    - Gross anatomy of typical root.
    - Secondary roots.
    - Specialized forms.
    - Tissues
      - Structure.
      - Distribution.
  - The flower
    - Typical structure.
    - Function of parts.
    - Morphological study of several parts.
    - Construction of diagrams.
      - Transverse.
      - Longitudinal.
  - The fruit
    - Structure with especial reference to changes from flower to fruit.
    - Morphological study of types.
  - The cell
    - Contents.
    - Structure.
    - Modifications.
    - Formation of tissues.
- **Physiology**
  - Rôle of water
    - Absorption.
    - Transfer.
    - Transpiration.
    - Turgidity.
    - Plasmolysis.
  - Photosynthesis
    - Rôle of chlorophyll.
    - Rôle of light.
    - Rôle of carbon dioxid.
    - Evolution of oxygen.
    - Study of starch grains.
  - Respiration
    - Rôle of oxygen.
    - Evolution of carbon dioxid.
  - Digestion
    - Action of diastase.
    - Translocation of food.
  - Irritability
    - Nature of stimulus.
    - Nature of response.
    - Geotropism.
    - Heliotropism.
    - Hydrotropism, etc.
  - Growth
    - Localization.
    - Amount of growth in seeds, stems, etc.
    - Relation to temperature, moisture, etc
  - Reproduction
    - Fertilization.
    - Sexual.
    - Asexual.

Ecology.—A study of plants in their reciprocal relations.
- Modifications for special functions.
- Dissemination.
- Cross pollination.
- Light relations.
- Plant societies
  - Mesophytes.
  - Hydrophytes.
  - Halophytes.
  - Xerophytes.
  - Climbers.
  - Epiphytes.
  - Parasites.
  - Saprophytes.
  - Insectivorous plants.
  - Symbiosis.
  - Plant associations.
  - Zonal distribution.

BOTANY II.—NATURAL HISTORY AND CLASSIFICATION.

Classification.
Structure.
Reproduction.
Homologies.
Adaptations.

Types for study
- Algæ
  - Pleurococcus.
  - Spirogyra.
  - Vaucheria.
  - Fucus.
- Fungi
  - Bacteria.
  - Yeasts.
  - Rusts.
  - Smuts.
  - Mildews.
  - Toadstools.
  - Puffballs.
- Lichens
  - Parmelia.
- Bryophytes
  - Hepatics (Marchantia or Porella).
  - Mosses.
- Pteridophytes
  - Ferns.
  - Horsetails.
  - Lycopodium.
- Gymnosperms
  - Pine.
- Angiosperms
  - Monocotyledon.
  - Dicotyledon.

METEOROLOGY—60 HOURS.

The course here outlined assumes some knowledge of general weather changes as illustrated on the daily weather map and as recommended by the conference on geography of the National Educational Association in 1893 for the lower schools, and that the student has taken an elementary course in physics in the high school or first year in college, and especially has precise knowledge of mass, volume, density; force, inertia, velocity, rotation, centrifugal force; gravitation, gravity, weight; atom, molecule; solid, liquid, gas; expansion, heat, temperature, specific heat, latent heat.

Definition and scope.

- **The atmosphere (in general)**
  - Origin.
  - Composition.
  - Extent and weight.
  - Arrangement about the earth (relations to geosphere and hydrosphere).
- **Temperature**
  - Sources, nature, transmission of heat.
  - Variations.
  - Measurement.
  - Distribution over the earth.
- **Pressure**
  - General principles.
  - Measurement.
  - Distribution.
  - Relations to atmospheric circulation.
- **Circulation—general movements and local winds.**
  - Measurement.
  - Distribution.
  - Causes and modifying influence (convectional theory and effects of earth's rotation).
  - Classification.
- **Atmospheric moisture.**
  - Origin.
  - Measurement.
  - Distribution.
  - Condensation in form of
    - Dew.
    - Frost.
    - Clouds.
- **Storms**
  - Cyclones
    - Tropical.
    - Extratropical.
    - Anticyclones.
  - Thunderstorms.
  - Tornadoes.
- **Precipitation.**
  - Rainfall
    - Sources.
    - Measurement.
    - Distribution.
    - Relation to atmospheric circulation.
  - Snow, hail, etc.
- **Weather**
  - Of different zones and seasons.
  - Observation and prediction.
- **Climate**
  - Of different zones, elevations, and localities.
  - Variations.

GEOLOGY—120 HOURS.

The earth in its relation to the solar system.

- **Geognosy: The materials of the earth.**
  - The Atmosphere—composition, volume, and weight.
  - The Ocean—composition, volume, and weight.
  - The Solid Globe—dimensions, shape, and constitution
    - Elements constituting rocks.
    - Minerals constituting rocks.
    - Rocks.
  - The weathering of rocks and formation of soil
    - Principles involved
      - Action of the atmosphere and of heat and cold.
      - Chemical action of water.
      - Mechanical action of water and ice.
      - Action of plants and animals.
    - Considerations of special cases
      - Weathering of granite, gneiss, trappean rocks, sandstone, limestone, slate, etc.
      - Proportional amounts of various constituents removed or lost.
      - Physical manifestations of weathering—size and shape of resultant particles, and their chemical composition.
- **Dynamical Geology..**
  - Volcanoes, hot springs, and geysers.
  - Earthquakes.
  - Upheaval and depression.
  - Circulation of water in springs, rivers, and oceans.
  - Glaciers and glaciation.
  - Erosion and deposition.
  - Metamorphism.
- **Structural Geology..**
  - Architecture of the earth's crust, stratification and bedding, jointing, cleavage, mode of occurrence of rock masses.
- **Stratigraphic Geology (Historical Geology).**
  - General principles.
  - Development of life.
  - Development of continents.
- **Man as a Geological Agent.**
  - The earth as modified by human action; effects of deforestation, etc.
- **Economic Geology...**
  - Ore deposits—occurrence and mode of deposition.
  - Ores of the metals.
  - The nonmetallic minerals.
  - Building and decorative material.
  - Road metal.
  - Mineral waters, artesian waters, etc. (hydrography).
  - Soils—surveys and mappings.
- **Physiographic Geology.**
  - Physiography—its influence on distribution and development of the human race, etc.

PHYSIOLOGY—180 HOURS.

Physiology is the science of the functions of living tissue (here confined to animals). The main facts and theories of animal physiology apply to man and the various domesticated animals, and constitute the subject of general physiology. If preferred, a course in human physiology covering substantially the same topics may be substituted. In the agricultural college the hygiene of domesticated animals will ordinarily be taught under the separate subject of zootechny, and the same may be said for metabolism and digestion in different species of animals. Illustrative materials and simple demonstrations will be used in connection with the lectures or text-book.

Definitions, problems, methods of study.

- **Protoplasm**
  - Composition.
  - Functions
    - Metabolism.
    - Change of form.
    - Movements.
    - Development of energy.
    - Irritability.
    - Reproduction.

Physical and chemical conditions of animal life.
Mechanics of animal life.

- **Digestion**
  - Saliva.
  - Gastric juice.
  - Bile.
  - Pancreatic juice.
  - Intestinal juices.
  - Lacteals and lymphatics.
  - Mechanism of digestion.
  - Absorption.
  - Assimilation.
  - Distribution of the products of digestion.
- **Blood**
  - Composition and elements.
  - Distribution in the body.
- **Respiration**
  - Respiratory changes in the blood and tissues.
  - Oxygen, carbon dioxid, and nitrogen in the blood.
  - Mechanics of respiratory movements.
  - Nervous control of respiration.
  - Relations of circulatory and respiratory systems.
- **Excretion**
  - Composition and excretion of urine.
  - Excretion of sweat and nature and amount of perspiration.
  - Feces.
- **Circulation**
  - Structure of heart, arteries, veins, and capillaries as related to their functions.
  - Course of circulation.
  - Mechanics of circulation.
  - Nervous control.
  - Blood pressure.
  - Pulse.
  - Fluctuations in quantity of blood.
- **Muscular action**
  - Simple muscular contraction.
  - Relation of nervous and muscular systems.
  - Changes in muscles during contraction
    - Chemical.
    - Thermal.
    - Electrical.
  - Conditions which determine muscular irritability and action.

- **Nervous system.**
  - Brain
    - Structure and anatomy of brain as related to nervous functions.
    - Localization of motor and sensory areas in the brain.
    - Conditions of cerebral action.
  - Spinal cord
    - Structure and functions.
    - Reflex action.
  - Special senses
    - Sight
      - Structure and optical principles of the eye.
      - Function of various parts of the eye.
    - Hearing...Structure and functions of the ear.
    - Smelling ..Structure and functions of the nasal fossæ.
    - Taste .....Functions of various organs concerned in this sense.

- **Reproduction**
  - Function of various organs.
  - Nutrition of the fetus.

- **Comparative physiology.**
  - Comparative study of various functions in animals and man, e. g., digestion in man, horse, cow, sheep, hog, and chicken.

ZOOLOGY—120 HOURS.

Zoology is the science of animal life in its broadest sense. In agricultural colleges the subject-matter of zoological courses is perhaps best largely confined to a study of the anatomy, habits, distribution, and natural enemies of the important injurious and beneficial species. The special economic aspects of domesticated mammals and birds would naturally be taught under zootechny, while the general subject of the interrelations of animals to man comes under the subject of zoology. An outline course in economic entomology is provided in connection with the course in zoology. The course, as a whole, provides for forty to forty-five lectures, and about eighty practicums (of two hours each).

Definition and general orientation.

- **Classification**
  - Protozoa.
  - Cœlenterata.
  - Echinodermata.
  - Mollusca.
  - Vermes.
  - Arthropoda.
  - Bryozoa.
  - Brachiopoda.
  - Tunicata.
  - Vertebrata
    - Fishes.
    - Amphibians.
    - Reptiles.
    - Birds.
    - Mammals.

- **Gross anatomy**
  - Discussion and study of types of various groups.
  - Comparative morphology of organs in various groups.
  - Anatomical evidences of relationship and evolution.

- **Microscopical anatomy**
  - Simple cell.
  - Muscle cell.
  - Gland cell.
  - Bone cell.
  - Nerve cell.
  - Various forms of tissue.
- **Development, embryology**
  - Fertilization.
  - Segmentation of egg.
  - Germinal layers.
  - Origin of organs.
  - Study of types.
  - Embryological evidences of relationship.
- **Distribution**
  - Means of distribution.
  - Laws of distribution.
  - Natural barriers and life zones.
- **Economic aspects of animal life.**
  - Feeding habits of various groups.
  - Interrelation of various groups.
  - Usefulness of animals and economic animal products.
  - Direct relationship of animals to agriculture
    - Birds.
    - Mammals.
    - Insects (Entomology)
      - Classification.
      - Habits.
      - Life history.
      - Useful species.
      - Injurious species.
      - Means of repression
        - Parasitic insects.
        - Predaceous insects.
        - Fungus diseases.
        - Cultural methods.
        - Mechanical methods
          - Barriers.
          - Tar bands.
          - Traps.
          - Ditches, etc.
          - Heat.
          - Cold.
        - Chemical methods
          - Dry insecticides
          - Spraying
            - Contact insecticides.
            - Poisons.
            - Spraying calendar.

Recommended for publication.

A. C. True, *Director*.

Publication authorized.

James Wilson, *Secretary of Agriculture*.

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